

Both the method and matter of this paper are unique. The results are obtained by a simple geometrical study of rolling circles. And there for the first time definite reasoning is adapted to the actual proportions of deep-sea waves, all previous work on the subject having been based on the assumption that the height of the wave is small compared with its length.

It is however in the next paper that he first shows what may be done by Maxwell's method of the graphic use of families of surfaces or curves. Here we have what is invisible in the fluid itself and had only been expressed by complex algebraical formulæ—the internal motion of the fluid—shown in such a way that not only the direction but the magnitude of the motion at every point may be taken in at a glance as well as definitely measured, and all deduced by simple but rigorous geometrical methods. The credit of this, which is certainly one of the highest achievements in the art of expression, must be divided. It was Faraday who first conceived the force of a magnet expressed by a family of lines; and it was Maxwell who discovered the rigorous method of drawing Faraday's lines; while Rankine realised in this the means of applying and expressing the principles of the steady flow of fluids propounded by Stokes now forty years ago.

In these papers on Hydrodynamics, as in all his other work, Rankine had a practical purpose in view. In this case it was the skin resistance and wave resistance of ships. And if, owing to the neglect of friction in the fundamental equations of motion, some of the results are still doubtful, yet in this respect the work is on a par with all the rest that has been done on this subject. And these papers, owing to the clear conception they convey of the internal motions of fluid and the direct purpose of the means adopted to elucidate these, afford by far the best chance for any one wishing to pursue the subject up to the highest position it has at present attained.

That Rankine himself owed much to having early directed his thoughts to fluid motion appears in all his work, as well as being shown by his theory of molecular vortices—a strictly hydrodynamical conception—amongst the intricacies of which nothing but his exact knowledge of the subject could have kept him straight.

It must be remembered however by those who would make a like use of such knowledge that Rankine did not begin his career by the study of mathematics; but that as an engineer from his birth, as we are told in the Memoir, he first became aware of the circumstances and problems of mechanics, and only evolved or acquired his mathematics as he found them necessary to his work. In this way his knowledge of mathematics must have included the knowledge of the necessity for each step. It was necessity first, and then method or invention; and not, as is too often the case with those who begin to learn mathematics before they are aware of what it is they are to do, all means and no ends.

In Rankine's text-books, as in his original papers, the ends are always kept in view. It is often impossible for others to follow him unless they begin by actually mastering the circumstances of the problem and trying to solve it for themselves, then if they honestly fail they will find that Rankine will help them; while if they succeed they will find that Rankine was before them. These books, both as regards originality of matter and the attention

paid to the circumstances of each problem, have more the character of original papers than orthodox text-books. From this as well as his other writings it is clear that he acquired his knowledge of mathematics from the original works of the master, and not from text-books.

His example should therefore be the best recommendation for all those who would really understand mechanics to read the works direct from the hand of this master—a task which, with the aid of this volume, they may now accomplish without that trouble of search which, small as it is, leaves many a masterpiece on the shelf in some dark corner, while a mutilated and garbled extract disgusts the reader and discredits the thinker.

OSBORNE REYNOLDS

THE FERNS OF NORTH AMERICA

The Ferns of North America; Coloured Figures and Descriptions, with Synonymy and Geographical Distribution, of the Ferns of the United States of North America and British North American Possessions. By D. C. Eaton, Professor of Botany in Yale College. The Drawings by J. H. Emerton and C. E. Faxon. 2 Vols. quarto, pp. 352 and 285; 81 Plates. (Boston: S. E. Cassino, 1880.)

THIS handsome work, which has been brought out in parts, issued about one every two months, beginning with 1878, is now completed. Although ferns have long been popular in the United States, both with collectors and cultivators, this is the first large illustrated monograph of the indigenous species which has been attempted. For our own country we have several, of which the best known are Hooker's "British Ferns," with coloured figures, in large octavo; Lindley and Moore's "Nature Printed Ferns," in more than one edition; and Newman's "British Ferns," in which the plates are uncoloured woodcuts; but of the American ferns there are but few figures, and those widely scattered in general works, and even leaving figures out of the question there has been no descriptive handbook specially devoted to them, so that those who wanted to work at the subject have been placed at a great disadvantage. Prof. Eaton, who is the grandson of a well-known botanical author, has been universally recognised for the last twenty years as the leading authority on the subject. He has a large library and general collection of his own, has visited Europe and studied the American ferns in the public herbaria of the Old World, has proved himself in other departments of botany to be a careful and judicious systematist, and he is a teacher of botany of many years' experience, and has been looked up to for a long time by all the collectors of ferns throughout the Union as their referee in cases of doubt and difficulty; so that he has had every advantage for dealing with his subject in a thorough and exhaustive manner, and as he has been ably seconded by his two artists, the result is a monograph which is thoroughly satisfactory in every way, and which will be universally accepted both at home and in Europe as a standard work.

The geographical area which it covers is the whole of the American continent, from the Pole to the southern boundary of the United States. The true ferns only are included, not the Lycopodiaceæ, Equisetaceæ, and Rhizocarps, which are monographed along with the ferns by

Hooker, Milde, and in the earlier editions of Newman. In North America the order is represented by 139 species and 31 genera. The number of species is quite double what we have in the whole of Europe. The northern area outside the United States produces very few species that have not been found within the bounds of the Union. As in Europe there are no Cyatheaceæ, Marattiaceæ, nor Gleicheniaceæ. Of the other sub-orders the Schizæaceæ, which we do not possess, are represented in the United States by three genera and four species. Ceratopteris, of which Prof. Eaton makes a special sub-order, is also American, but not European. The other four sub-orders—Polypodiaceæ, Hymenophyllaceæ, Osmundaceæ, and Ophioglossaceæ—are represented, both in America and Europe. One peculiarity of ferns is that the genera show exceedingly little tendency to geographical localisation. The nearest approach to this that we have in North America is the predominance of Pellæa, Cheilanthes, and Nothochlæna, which are allied dwarf types with a greater power of resisting drought than any other set of ferns, and which are represented in this area by a large proportionate number of endemic species. These three genera take up thirty-nine species in North America against four for Europe. Out of the 139 species about forty are endemic, and about forty are European, the latter including several of our high mountain types, such as *Cystopteris montana*, *Aspidium Lonchitis*, *Polypodium alpestre*, *Woodsia ilvensis*, *glabella*, and *hyperborea*. The southern boundary of the States corresponds broadly with the limit in a northern direction of the great tropical flora of Equatorial America, the richest tropical flora in the world. But out of the 139 ferns at least twenty are characteristically widely-spread tropical species which do not extend beyond Florida, which have several of them only been discovered there within the last few years. Such are *Ophioglossum palmatum*, *Aerostichum aureum*, *Polypodium aureum*, *P. Phyllitidis*, *P. Plumula*, and *P. pectinatum*, *Vittaria lineata*, and *Nephrolepis exaltata*. Amongst the remaining species there are some curious cases of a rôle of distribution it is difficult to explain or understand. *Adiantum pedatum* and *Osmunda cinnamomea* are examples in ferns of a considerable group of American plants which reach Asia by way of Japan and run down through China to the Eastern and Central Himalayas; *Pteris serrulata*, found lately in America in Alabama, and South Carolina, reappears only in China; *Pellæa andromedæfolia*, which from California passes down the Andes to Chili, reappears in Cape Colony. *Nothochlæna tenera* is supposed to be divided between Southern Utah and the Andes of Bolivia and Chili, but here I think that the States plant will most likely have to rank as a distinct species. *Aspidium mohrioides*, long supposed to be endemic in extra-tropical South America, has been discovered lately by Mr. Moseley in Marion Island, and by Mr. Lemmon in one place at an elevation of 8000 feet above sea-level amongst the mountains of California.

As regards the limitation of genera and species Prof. Eaton differs but little from Sir William Hooker, as the English author's views are expounded in his great monograph of the ferns of the whole world, his "Species Filicum." Prof. Eaton treats Hymenophyllaceæ and Ceratopterideæ as distinct sub-orders; the former at any

rate a decided improvement upon Sir W. Hooker's classification, and he maintains Ophioglossaceæ as a distinct order. In genera the principal deviations are that he keeps up Phegopteris as distinct from Polypodium, and merges Nephrodium in Aspidium.

A very curious North American fern is *Asplenium ebenoides* of Scott. It is very rare, and always grows in company with the walking leaf (*Camptosorus rhizophyllus*) and *Asplenium ebeneum*, two common American species. These are very dissimilar plants, but *A. ebenoides* is quite intermediate between them. Prof. Eaton seems not disinclined to the idea that it may be produced by natural hybridisation, as was suggested by the Rev. M. J. Berkeley in the *Journal* of the Royal Horticultural Society for 1866, p. 87.

An observation of Prof. Eaton's under *Nothochlæna Fenaleri* is interesting as bearing upon Milde's classification of ferns into a catadromous and anadromous series, according as to whether their lowest secondary branches originate on the posterior or anterior side of the pinnæ. Prof. Eaton notes that in this species there is always a decided inequality in their origin; but that it is sometimes on the anadromous, and at others on the catadromous plan.

J. G. BAKER

KÖLLIKER ON ANIMAL DEVELOPMENT

Grundriss der Entwicklungsgeschichte des Menschen u. der höheren Thiere. Von Albert Kölliker, Professor der Anatomie an der Universität Würzburg. (Leipzig: W. Engelmann, 1880.)

THIS book is essentially a reproduction of Prof. Kölliker's large treatise on Embryology, with a great part of the detail and controversial matter omitted, and is intended for the use of medical students. The larger work has more the character of a monograph on the development of birds and mammals than of a text-book; and as such, though of very great value to those engaged in teaching and research, is necessarily too bulky for the use of ordinary students. We think, therefore, that Prof. Kölliker has done very wisely in publishing the work before us; and we need hardly say that, his larger treatise having been already universally recognised as one of the most important contributions to embryology during recent years, the present work may safely be regarded as an accurate statement of the facts of avian and mammalian embryology. We may add that no trouble has been spared in the illustrations, which fully come up to the high standard characteristic of German works of this class.

While, however, we can say this much in praise of Prof. Kölliker's treatise, we cannot help recognising that it has some rather serious defects. Prof. Kölliker is an extremely objective writer. He describes with great clearness the objects as they present themselves to the observer, but he scarcely ever attempts to connect them together or to point out the general principles which underlie the mass of detail with which he has to deal. In his larger work this peculiarity is of comparatively small importance, in that those who are likely to use it are able to supply the general principles for themselves; and the work has already become a great mine of facts to which every anatomist who is engaged in studying the morphology of vertebrates will necessarily turn.